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Tool Rig for the Compaction of Particulate Material

Background of the Invention

Cross Reference to Related Application

This application claims the benefit of U.S. provisional application Serial No. 60/348,972, filed January 15, 2002.

Field of the Invention

The present invention relates to the art of forming products from particulate materials. More particularly, the present invention relates to the compaction of particulate materials. Still more particularly, the present invention relates to a new tool rig for the compaction of particulate materials.

Description of Related Art

In the manufacture of components or parts from particulate materials, a critical process is the compaction of the particulate material. Compaction is typically performed by filling a die cavity with the particulate material and applying pressure to the particulate material with a press.

The press has a driven main ram that moves in a single direction. The main ram is connected to a ram platen that moves with the main ram. In most cases, the main ram and ram platen move in a downward direction toward a base platen to perform the compaction. The main ram may be driven by hydraulic or mechanical means, as known to those skilled in the art. Depending on the operation, additional rams may be present to provide auxiliary motion in a coaxial direction.

For compaction different types of presses may be utilized, among them a hybrid press and a hydraulic press. A hydraulic press includes a hydraulically driven main ram and hydraulic auxiliary motions. A hybrid press comprises a crank or knuckle driven main ram and hydraulic auxiliary motions. Adjustable mechanical stops are used to prevent auxiliary motion beyond the desired range.

A density close to the theoretical density of the material is desired for a component made from a particulate material, because the mechanical properties of the component improve with increasing density of the compacted particulate. As a result, techniques have been developed to increase the density achieved through the compaction process. These techniques are often focused on multiple level parts, because the geometry of multiple level parts usually make uniform density distribution between the levels more difficult. A discrepancy in density distribution adversely affects the performance of the part and may lead to the formation of cracks in the compaction process.

One technique to improve compaction of multiple level parts is that of a tool rig comprising a die that defines a cavity in conjunction with at least two punches that extend into the cavity. At least one punch is typically actuated through auxiliary motion at some point during the compaction process to move the punch to a different vertical position and thereby direct the flow of the particulate material in the cavity to achieve a more uniform density distribution in the formed part. For parts with many levels, multiple punches may be used and each punch may be separately actuated.

In order to facilitate these actuated punches, designs of prior art tool rigs have relied upon cumbersome designs. A tool rig usually includes

platens and/or cylinders to support each punch. Each of these support components must be independently movable to allow each punch to be independently actuated. Likewise, each support component must have an independent source of energy to create independent motion of the support component and its respective punch. Such sources of energy may include connections to hydraulic or pneumatic media. Further, each support component typically has a linear encoder that measures the position and travel of the component, in turn measuring the position and travel of the punch that the component supports.

The requirement of an independent energy supply source for each component that supports an actuated punch has necessitated the design of vertically long tool rigs and presses in the prior art. The vertical length of a press dictated by designs of the prior art is illustrated in European Patent No. EP 0 586 028 B1, issued to the present inventor and others; in PCT Publication No. WO 01/08864 A1, issued to Beane et al.; and in European Patent No. 0 077 897/related U.S. Patent No. 4,482,307, issued to Schaidl et al. The excessive vertical length of these designs demands deep pits and/or high ceilings in a production facility, results in long tooling stack-ups that are difficult to align and increase set-up time, and yields a deflection that is generally high.

Accordingly, it is desirable to develop a new tool rig that integrates all necessary elements at a substantially reduced height, which provides increased rigidity and maintains good accessibility for set-up.

Summary of the Invention

The present invention provides a tool rig for the compaction of particulate materials such as powdered metals, which includes a supply

component to connect an energy supply to at least one piston from the inside of a piston.

In an exemplary embodiment of the present invention, a tool rig for the compaction of particulate materials includes a base and a cylinder block disposed on the base. At least two pistons are disposed within the cylinder block and one piston is at least partially disposed within one other piston. An energy supply is connected to at least one of the pistons from the inner diameter of a piston by means such as a supply component that defines a channel.

In another exemplary embodiment of the present invention, a tool rig for the compaction of particulate materials includes a base and a cylinder block disposed on the base. At least two pistons are disposed within the cylinder block and one piston is at least partially disposed within one other piston. A supply component is disposed in the inner diameter of at least one piston and defines at least two channels, wherein one channel provides an energy supply to one piston and one other channel provides an energy supply to one other piston.

In yet another exemplary embodiment of the present invention, a press for the compaction of particulate materials includes a frame and a tool rig for the compaction of particulate materials connected to the frame. The tool rig includes a base, a cylinder block disposed on the base and at least two pistons disposed within the cylinder block. One piston is at least partially disposed within one other piston and an energy supply is connected to at least one of the pistons by means such as a supply component. The supply component is disposed in the inner diameter of at least one of the pistons and defines at least one channel that provides connection to the energy supply.

Brief Description of the Drawings

The invention may take form in certain components and structures, exemplary embodiments of which will be illustrated in the accompanying drawings, wherein:

FIG. 1 is a front sectional view of a tool rig in accordance with an embodiment of the present invention;

FIG. 2 is a plan sectional view of the tool rig of FIG. 1 along line A-A;

FIG. 3 is a plan sectional view of the tool rig of FIG. 1 along line B-B;

FIG. 4 is a sectional view of the tool rig of FIG. 3 taken along line C-C;

FIG. 5 is a front sectional view of a tool rig in accordance with another embodiment of the present invention in a fill position;

FIG. 6 is a front sectional view of the tool rig of FIG. 5 in a compacting position;

FIG. 7 is a front sectional view of the tool rig of FIG. 5 in an ejection position.

FIG. 8 is a front sectional view of a lower half of a tool rig in accordance with yet another embodiment of the present invention;

FIG. 9 is a plan sectional view of the tool rig of FIG. 8 taken along line A-A;

FIG. 10 is a front sectional view of an upper half of a tool rig in accordance with the embodiment FIG. 8;

FIG. 11 is a front sectional view of a tool rig in accordance with still another embodiment of the present invention;

FIG. 12 is a plan sectional view of the tool rig of FIG. 11 taken along line A-A; and

FIG. 13 is a sectional view of the tool rig of FIG. 12 taken along line B-B.

Detailed Description of the Preferred Embodiments

With reference to FIGS. 1-4, a tool rig **10** to support tooling members is shown. Tooling members include punches, core rods and dies, as are required to form a part from particulate materials. Turning first to FIG. 1, the tool rig **10** includes a cylinder block **12** and a base **14**. The cylinder block **12** and the base **14** may be collectively referred to as a housing. The tool rig **10** also includes a first, outer piston **16** and a second piston **18** inside of the first piston **16**, each of which can support a separate tooling member movable along the vertical axis of the tool rig **10** in response to the supply of an energy source, such as hydraulic fluid. Means for connecting an energy source, such as a stationary supply component **20**, are disposed in the inner diameter of the second piston **18**. The energy source includes hydraulic or pneumatic pressure media.

A third, central piston **24** to actuate an additional tooling member may be disposed in the supply component **20**. In the tool rig **10**, the third piston **24** is at least partially on the same elevation as the second piston **18**. That is, the height at which the lower limit of vertical travel of the third piston **24** occurs is at approximately the same height at which the lower limit of vertical travel of the second piston **18** occurs. It is to be noted that the supply component **20** may be an integral part of the housing **12** and **14** of the tool rig **10**. As a result, the cylinder block **12**, the base **14** and the supply component **20** cooperate to

contain, support and supply an energy source to the movable pistons **16**, **18** and **24**.

The supply component **20** allows an energy supply to be connected to the second piston **18** from the interior of the second piston **18**, as well as to the third piston **24**. The base **14** houses a linear encoder **26** for the first piston **16**, a linear encoder **28** for the second piston **18** and a linear encoder **30** for the third piston **24**.

A first channel **32** and a second channel **34** are defined in the base **14** of the tool rig **10** and continue through the supply component **20** for the connection of an energy supply, such as hydraulic fluid, to the second piston **18**. A first annular pocket **36** is defined between the second piston **18** and the supply component **20**. The first pocket **36** includes an upper portion **38** and a lower portion **40**. A second, higher, annular pocket **41** is also defined between the second piston **18** and the supply component **20**. The second piston **18** includes a first radial projection **42** about its inner circumference that rides within the first pocket **36** and a second radial projection **43** that forms the upper wall of the second pocket **41**. The first channel **32** supplies hydraulic fluid to the lower portion **40** of the first pocket **36** and to the second pocket **41** to urge both projections **42** and **43**, and hence the second piston **18**, upward. The second channel **34** supplies the upper portion **38** of the first pocket **36** with hydraulic fluid to urge the projection **42**, and thus the second piston **18**, downward. In this manner, the travel of the tooling member supported by the second piston **18** is controlled.

A third annular pocket **44** is defined in between the supply component **20** and the third piston **24**. Hydraulic fluid is supplied to the third

pocket **44** through channels (**57** and **58** in FIG. 2) in the supply component **20** to control the movement of the third piston **24**, and the tooling member that it supports, in the manner described for the second piston **18**.

With continuing reference to FIG. 1, a fourth annular pocket **45** is defined between the cylinder block **12** and the first piston **16**. A radial projection **46** extends about the outer circumference of the first piston **16** and rides within the fourth pocket **45**. The hydraulic fluid is supplied to the fourth pocket **45** through channels (not shown) in the outer wall of the cylinder block **12** to control the movement of the projection **46**, and thus the first piston **16** and the tooling member that it supports.

Upper and lower adjustable mechanical stops **47** and **48** may be included in the tool rig **10** to allow the first piston **16** and the second piston **18** to have an adjustable lower limit of movement. The upper adjustable stop **47** includes a first inner ring **49** having an external thread that connects to an internal thread of a first outer ring **50**. The first outer ring **50** may be rotated by a first worm gear shaft **51**. Likewise, the lower adjustable stop **48** includes a second inner ring **52** that has an external thread that connects to an internal thread of a second outer ring **53**, which in turn may be rotated by a second worm gear shaft **54**. A first guide rod **55** and a second guide rod **56** are fixed to the first and second pistons **16** and **18**, respectively, and are guided in the base **14** to keep the inner rings **49** and **52** from rotating. Therefore, if the outer rings **50** and **53** are rotated, the respective inner rings **49** and **52** will be moved vertically and will thus change the lower limit of movement for the pistons **16** and **18**. It is also to be noted that adjustable mechanical stops using threaded rings,

as described, are provided by way of example only, as other adjustment mechanisms known in the art, such as wedges, may be used.

FIG. 2 illustrates the base **14** of the tool rig **10** from a plan sectional view. The detail of the upper mechanical stop **47**, which supports the first piston **16,** can be seen. In particular, the first worm gear shaft **51** that drives the rotation of the first outer ring **50** and the first guide rod **55** that prevents rotation of the inner ring **49** are apparent.

FIG. 2 further illustrates the first and second supply channels **32** and **34** defined by the supply component **20** for the actuation of the second piston **18** (referring back to FIG. 1) and the third and fourth supply channels **57** and **58** also defined by the supply component **20** for the actuation of the third piston **24.**

With reference to FIG. 3, the concentric relationship between the first piston **16**, the second piston **18**, the supply component **20** and the third piston **24** in the cylinder block **12** is further illustrated. A die platen **59** (referring back to FIG. 1) includes connecting lateral pistons **60** that extend into the cylinder block **12**. Additional detail of the interaction between the cylinder block **12** and the connecting lateral pistons **60** is shown in FIG. 4. The connecting lateral pistons **60** extend into corresponding chambers **61** defined in the cylinder block **12**. Typically, two (2) or four (4) connecting lateral pistons **60** are present.

Turning now to FIGS. 5-7, actuation of a similar, yet alternative, embodiment of a tool rig **62** is illustrated. The tool rig **62** is similar to the tool rig **10** described in FIGS. 1-4, without an adjustable mechanical stop. In place of adjustable mechanical stops are simple positive stops. FIG. 5 shows the tool rig **62** in a fill position. The tool rig **62** may include a die platen **64** that houses a die

adapter **66**. The die adapter **66** receives a die **68** that defines a cavity **70**, which holds the particulate material or pre-form that is compacted by use of the tool rig **62**. On top of a second piston **72** is an adapter **74** that facilitates the support of an inner punch **76** by the second piston **72**. Surrounding the second piston **72** is a first piston **78**. The first piston **78** supports an adapter **80**, which in turn supports an outer punch **82**. This system of pistons **72** and **78** and adapters **74** and **80** allows the outer punch **82** and the inner punch **76** to extend into the cavity **70** when the tool rig **62** is in the fill position. Disposed in the center of the supply component **83** is a third piston **84** that actuates a core rod **86** that extends into the cavity **70**.

With reference to FIG. 6, an upper punch **88** may have entered the cavity **70** when the tool rig **62** is in a compaction position. FIG. 7 illustrates the tool rig **62** in an ejection position, where a compacted part **90** is pushed out of the die **68** by the punches **76** and **82**. The fill-compaction-ejection cycle shown in FIGS. 5-7 illustrates the movement of the concentric pistons **72**, **78** and **84**, which remain on essentially the same level or elevation throughout their operation, facilitated by the supply component **83**.

Turning to FIGS. 8-10, yet another embodiment of a tool rig **92**, designed to support three upper and three lower tooling members, is shown. With reference to FIG. 8, the tool rig **92** includes a lower half **94**. The lower half **94** of the tool rig **92** includes a cylinder block **96** and a base **98**. Housed within the cylinder block **96** are a first, outer concentric piston **100**; a second, middle concentric piston **102**; and a third, inner concentric piston **104**. These pistons **100**, **102** and **104** provide support for the lower tooling members (not shown) and are movable along the vertical axis of the tool rig **92** in response to the

supply of an energy source, such as hydraulic fluid. A central bore **106** for an externally operated central tooling member (not shown) is defined in the inner diameter of the third piston **104**. Disposed between the second piston **102** and the third piston **104** is a stationary supply component **108**. The supply component **108** allows access to the second piston **102** and the third piston **104** for the supply of the energy source from a lateral position between the pistons **102** and **104**.

Housed within the base **98** of the lower half **94** of the tool rig **92** are linear encoders. A linear encoder **110** for the first piston **100**, a linear encoder **112** for the second piston **102** and a linear encoder **114** for the third piston **104** are all mounted within the base **98**. The encoders **110, 112** and **114** extend from the base **98** into each respective piston **100**, **102** and **104** and measure the travel of each respective piston **100**, **102** and **104** throughout the compaction cycle.

The base **98** also defines supply channels that facilitate the connection of an energy supply, such as hydraulic fluid. For example, an upper supply channel **116** and a lower supply channel **118** are defined in the base **98** of the tool rig **92** and continue into the supply component **108**. A first annular pocket **120** is defined by the second piston **102** and includes an upper portion **122** and a lower portion **124**. The supply component **108** includes a first radial projection **126** that extends into the first pocket **120** to create the limits of vertical travel for the second piston **102**. The lower channel **118** supplies the hydraulic fluid to the lower portion **124** of the first pocket **120** to urge the second piston **102** upward. The upper channel **116** supplies the upper portion **122** of the pocket **120** with hydraulic fluid to urge the second piston **102** downward.

The third piston **104** defines a second annular pocket **128** into which a second radial projection **130** from the supply component **108** extends. Thus, the third piston **104** may also be supplied with an energy source, such as hydraulic fluid, to cause vertical movement, as described above for the second piston **102**.

The first piston **100** includes a third radial projection **132** about its outer circumference that rides within a third annular pocket **134** defined in the cylinder block **96**. The third pocket **134** for the first piston **100** is connected to the energy supply through a channel (not shown) defined in the cylinder block **96**, typically through the outer wall of the cylinder block **96**. As with the second **102** and the third **104** pistons, the limits of the third projection **132** in the third pocket **134** within which it rides dictate the travel of the first piston **100** and the tooling member it supports.

A die platen **136** is tied to a connecting plate **138** by columns **140**, which pass through the cylinder block **96** and the base **98**. The connecting plate **138** in turn ties to an external drive provided by the press (not shown).

Turning now to FIG. 9, a plan sectional view of the base **98** of the lower half **94** of the tool rig **92** is illustrated. A port **142** for the linear encoder **110** of the first piston **100** is defined in the base **98**, as are ports **144** and **145**, for the encoders **112** and **114** of the second piston **102** and the third piston **104**, respectively. The energy supply channels **116** and **118** for the second piston **102** and energy supply channels **146** and **147** for the third cylinder **104** are shown. The location of the columns **140** that tie the die platen **136** to the connecting plate **138** (referring back to FIG. 8) are also shown.

Depending upon the particular application, it may be desirable to actuate multiple punches from a position above the die platen **136** (referring back to FIG. 8) in addition to a position below the platen **136**. When multiple punches are used above the platen **136**, the tool rig **92** may include an upper half **148**, shown in FIG. 10. The upper half **148** of the tool rig **92** is located above the die platen **136** and is substantially a mirror image of the lower half **94** that is located below the die platen **136**. Due to such similarity, the upper half **148** will be understood based upon the foregoing description of the lower half **94**. Of particular note is a third, central piston **149** similar to the central piston **104** of the lower half **94**, except the central piston **149** of the upper half **148** does not have a central bore. Of course, any embodiment of the tool rig described herein may include an upper half in addition to a lower half. Also, an upper half or a lower half of the tool rig of the present invention may be combined with a respective lower or upper half of a tool rig of the prior art.

With reference to FIGS. 11-13, a lower half **150** of still another embodiment of a tool rig **152** is shown. In this embodiment, a first concentric piston **154**, a second concentric piston **156**, a third concentric piston **158** and a fourth concentric piston **159** are present. However, a cylinder block **160** that houses the pistons **154**, **156**, **158** and **159** is extended vertically (as compared to the prior embodiments) and includes a top cylinder block portion **160a** and a bottom cylinder block portion **160b**. In addition, a supply component **161** is disposed within the inner diameter of the third piston **158**. As a result, the third piston **158** and the fourth piston **159** are supplied from a base **162** of the tool rig **152** through the supply component **161**, as described in the above embodiments. Both the first and second cylinders **154** and **156** are supplied

through the outer wall of the cylinder block **160**, i.e., the first piston **154** is supplied through the outer wall of the upper cylinder block portion **160a** and the second piston **156** is supplied through the outer wall of the lower cylinder block portion **160b**.

In this manner, only some of the pistons, i.e., the second, third and fourth pistons **156**, **158** and **159**, may be on one level, while one or more pistons, such as the first piston **154**, is on a different level. In such an embodiment, the overall length of the tool rig **152** is not substantially increased from that of the prior embodiments, as more than one piston (i.e., **156**, **158** and **159**) are on the same level and tool adaptation for the tooling members supported by these pistons may be at least partially on the level of the first piston **154**, thereby decreasing the minimum gap required between a die platen **164** and the cylinder block **160.**

As shown in FIGS. 12 and 13, the die platen **164** may include connecting lateral pistons **166** that extend into the lower half **150** of the tool rig **152**, similar to the manner described above in FIG. 4. The cylinder block **160** defines chambers **168** into which the corresponding connecting lateral pistons **166** extend. The cylinder block **160** also defines a shoulder **170** that extends into each chamber **168**, which cooperates with a flange **172** on each connecting lateral piston **166** to define the lower limit of vertical travel of the connecting lateral pistons **166**, and hence, the die platen **164**.

The use of the supply component reduces the excessive height required for a press that compacts parts made from particulate materials using multiple punches. This reduces the deflection of the press and the tooling stack-up, and also eases the alignment of the tooling members, thereby increasing the

quality of the parts made. In addition, the press occupies less vertical production space.

The above examples have described in detail a tool rig in a modular design to allow multiple rigs to be interchangeably used on a single press. However, it is also anticipated that a press may be designed with the tool rig of the present invention as an integral component. A press that may utilize the tool rig either as a modular unit or as an integral component includes a frame. The frame may provide main ram motion, actuation of the die and further tooling members, and electric, hydraulic or pneumatic controls.

Particular note is made that at least two concentric pistons of the tool rig of the present invention are at essentially the same level or elevation. Further, a base that is on a different level contains encoders and means to provide an energy supply to each concentric piston. The invention has been illustrated with respect to a tool rig that supports three or four tooling members, such as punches or core rods and a die. However, support of more punches or core rods may be accomplished using the design of the present invention. For example, five or six concentric cylinders may be employed, rather than three or four.

The invention has been described with reference to the preferred embodiments. Of course, modifications and alterations might occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of this disclosure.